U.S. ARMY DUGWAY PROVING GROUND, UTAH ENVIRONMENTAL AND ECOLOGY BRANCH TRIENNIAL PROGRESS REPORT 1977 THROUGH 1979

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The objective of the US Army Dugway Proving Ground, Utah, Environmental and Ecology Branch surveillance program has been to monitor the proving ground and adjacent areas for adverse impacts attributable to human activities or natural events, and to preclude deliterious effects of testing and related operations. As in previous years, the experimental observations recorded in this report show that no adverse impact occurred as a result of the military and civilian activities conducted at the proving ground.

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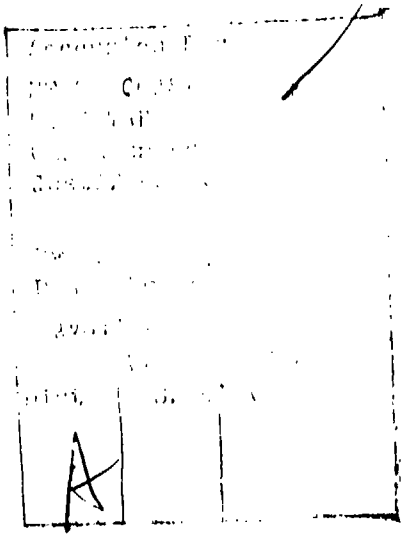
It was determined that (a) there were no abnormal fluctuations of the local jackrabbit populations, (b) the incidence of tularemia in jackrabbits appeared to decline slightly, (c) the incidence of tularemia in other species remained relatively unchanged, and (d) the levels of erythrocytic acetylcholinesterase of cattle and sheep surveyed were well within the baselines established for these animals. As a result of In-house Laboratory Independent Research, epidemiological conditions responsible for maintaining California encephalitis virus in western Utah were determined. In addition, valuable data were obtained which extend and refine the historical record of the dynamics of the jackrabbit population.



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ABSTRACT

The objective of the US Army Dugway Proving Ground (DPG), Utah, Environmental and Ecology Branch surveillance program has been to monitor the proving ground and adjacent areas for adverse impacts attributable to human activities or natural events, and to preclude deleterious effects of testing and related operations. As in previous years, the experimental observations recorded in this report show that no adverse impact occurred as a result of the military and civilian activities conducted at DPG from 1977 through 1979.

It was determined that (a) there were no abnormal fluctuations of local jackrabbit populations, (b) the incidence of tularemia in jackrabbits appeared to decline slightly, (c) the incidence of tularemia in other species remained relatively unchanged, and (d) the levels of erythrocytic acetylcholinesterase of cattle and sheep surveyed were well within the baselines established for these animals. As a result of In-house Laboratory Independent Research, epidemiological conditions responsible for maintaining California encephalitis virus in western Utah were determined. In addition, valuable data were obtained which extend and refine the historical record of the dynamics of the jackrabbit population.

FOREWORD

Investigations conducted in epidemiology, ecology, and toxicology by US Army Dugway Proving Ground (DPG), Utah, Environmental and Life Sciences Division were directed toward satisfying the requirements of organization, function, and mission (Reference 1, pages 19-11 and 19-12). Additional work was performed under TRMS No. 7-CO-1L9-DP1-001. The work dealing with indigenous arboviruses of Utah was performed under RDT&E Project Nos. 1T161101A91A (FY77) and 1L16110A91A (FY78/79).

In conducting the research described in this report, the investigators followed the "Guide to Laboratory Animal Facilities and Care" as issued by the Committee on the Guide for Laboratory Animal Resources, National Academy of Sciences, National Research Council.

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The following individuals contributed to the investigations reported in this publication.

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INTRODUCTION

Dugway Proving Ground has been charged with the responsibility for monitoring the epidemiological, ecological and toxicological impact for all activities and testing since 1951. This report covers the results of investigations conducted from 1977 through 1979, and constitutes the latest of a series of reports on environmental studies begun in the early 1950s. Although recent efforts have been maintained at a minimal level (one and one-half man years per annum), they still serve to ensure the safety of personnel and the environment.

OBJECTIVES

The objective of this program is to provide for the continuing, minimal environmental surveillance of the natural environment in the Dugway, Utah geographic area. The program includes the following: (a) evaluation of the potential for adverse effects of testing activities being performed at the US Army Dugway Proving Ground (DPG), Utah; (b) identification of potential environmental consequences caused by operations at DPG; (c) establishment of ecological baselines; and (d) conduct of other investigations needed to permit DPG to perform its assigned mission tasks. Publishing the results of these investigations represents an important contribution to the scientific literature and brings recognition to DPG, the Army and the investigators.

SECTION 1. ECOLOGICAL INVESTIGATIONS OF NATIVE FAUNA

1.1 BACKGROUND

Field observations and collections are the primary methods used to collect information on the ecology of native fauna. A number of species were studied in the past; however, for scientific and budgetary reasons, only investigations of the population dynamics of blacktailed jackrabbits (*Lepus californicus*) have been continued. Concentrating available resources on a single species is more productive and cost-effective. The blacktailed jackrabbit was selected as the sentinel species because: (a) its high population density and wide distribution provide adequate sample numbers for statistical evaluation, (b) its size and visibility during daylight hours simplify counting, (c) its breeding season is limited, and (d) jackrabbit population dynamics have been extensively studied by other investigators, permitting correlation and comparison of data.

Local fluctuations in the jackrabbit populations have been studied by several investigators (References 2, 3, and 4). The studies of the Bonneville Basin area of Dugway, Utah were started by the University of Utah in 1952 (under contract to the US Army) (Reference 2) and continued by Ecodynamics, Inc., Salt Lake City, Utah. In 1973, the program was undertaken in-house at a much reduced level of funding. The study thus represents an irreplaceable continuum of data spanning almost three decades.

The area studied is in the Great Salt Lake Desert and measures approximately 160 km from east to west and 80 km from north to south (Figure 1). The area is characterized as middle-latitude, dry climate, with hot dry summers and moderately cold winters. The average yearly rainfall is 17.6 cm with most of the precipitation occurring from December to May. Relative humidity normally ranges from 5 to 10 percent during the summer and 30 to 50 percent during the winter. The extremes in temperature have ranged from -27 to 43°C. Water from small springs is distributed sparsely throughout the area. Although wild horses depend on these water sources, jackrabbits probably obtain most of their water from plants and the dew formed in the early morning, particularly during the hot dry months.

Jackrabbits were counted on transects located on the vegetated segments of the study area (a U-shaped vegetated area that surrounds the barren clay flats within the described boundaries) (Figure 1). Transects were not made on the salt flats because jackrabbits do not live there.

The topography, climate, and vegetation of the study area are very similar to those studied by Gross *et al.* in the Curlew Valley (Reference 4), approximately 175 km north of the study area. Both areas are in the cool vegetative desert region described in Reference 5 as the Northern Desert Shrub Biome.

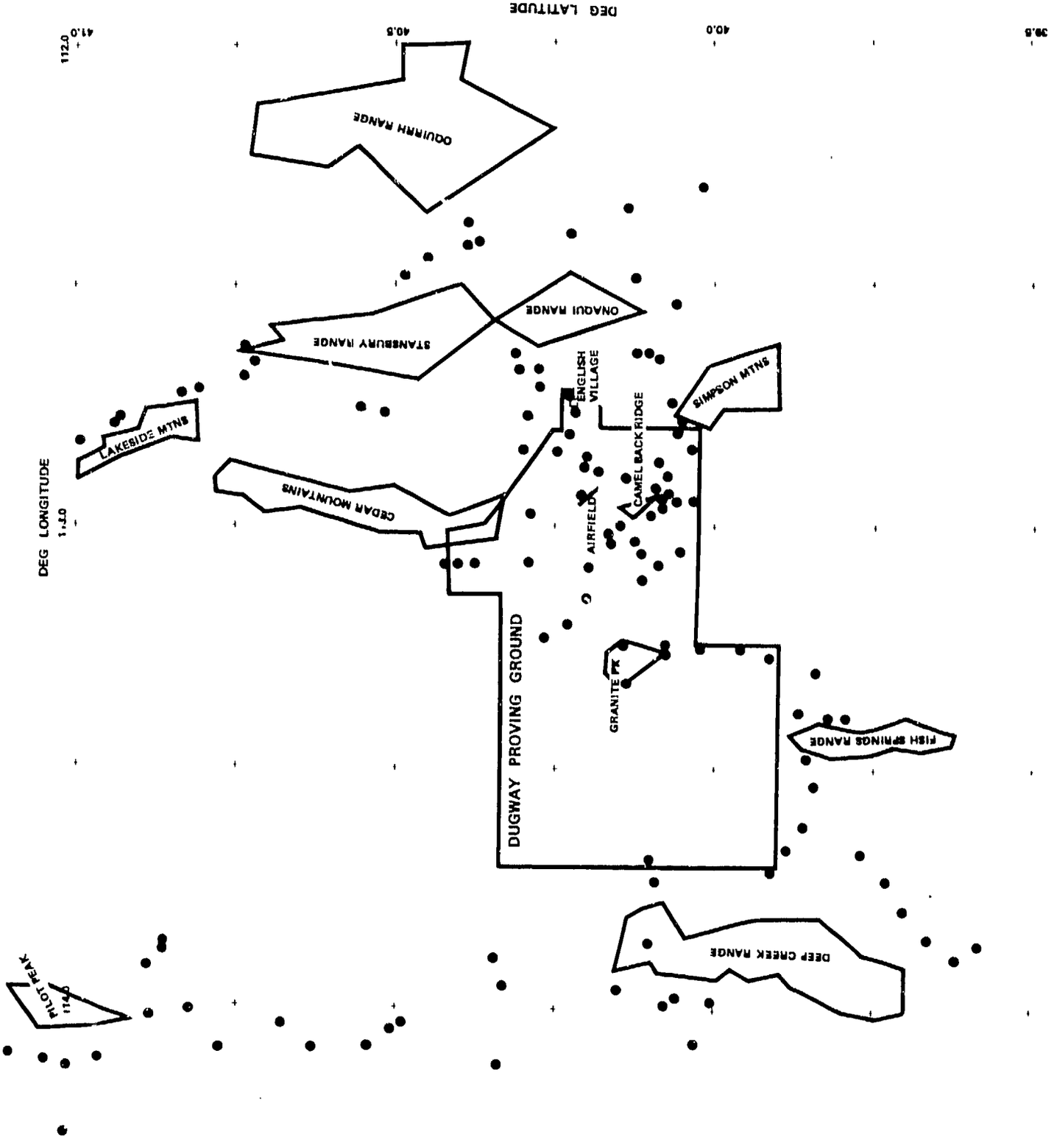

Figure 1. Blacktailed Jackrabbit Sampling Sites in the Southern Bonneville Basin

1.2 OBJECTIVES

a. To collect baseline data and other data indicative of any adverse environmental impact caused by human activities, or national events that may have occurred on or near US Army Dugway Proving Ground (DPG), Utah.

b. To design statistically valid methods for gathering data on local animal populations.

c. To interpret and report on the population dynamics of selected local animal species.

1.3 ACCOMPLISHMENTS

1.3.1 Methods

1.3.1.1 Jackrabbit Counts. Jackrabbits are counted semi annually (March and August) each year. The jackrabbits observed along 119 transects within the study area are counted. The locations of these transects are shown in Figure 1.

1.3.1.2 Estimate of Fertility. The number of breeding females is estimated to be one-half the animals counted in the spring census (March). Census results are calculated as numbers of jackrabbits per km but reported as density indices, as in Reference 4, because of uncertainties such as the possibility that some rabbits may be counted twice and others not observed.

The gestation period is assumed to be 43 days (Reference 7). The length of the breeding season is estimated from the time of the appearance of sufficient numbers of pregnancies (in the investigator's opinion) instead of from the first pregnancy found, which may occur one to two weeks earlier. Similarly, the end of the breeding season is estimated by averaging the last date of parturition of several females in their last pregnancy of the given season rather than the last birth date recorded. The number of pregnancies per female for each season is estimated by dividing the length of the breeding season (in days) by the average gestation period (43 days).

1.3.1.3 Determination of Juvenile Population. The portion of the population represented by the young of a given year is estimated by the methods in Reference 6.

To prepare these estimates, 30 to 50 rabbits in each of two areas (Dugway and Rush Valleys) are sacrificed during the fall (15 August to 10 November).

1.3.1.4 Indices of Jackrabbit Mortality. The methods in References 4 and 8 are used to obtain indices of jackrabbit mortalities as follows.

a. Winter Mortality (Entire Population). This value is estimated as the decrease in numbers of animals during the winter; i.e., the difference between the August census and the next March census.

b. Summer Mortality (Adult). This value is estimated from the decrease in numbers of adults in the population between the March census and the following August census. The August counts are reduced to adult counts by subtracting juvenile counts (Paragraph 1.3.1.3.).

c. Summer Mortality (Juvenile). The number of juveniles is estimated from the fertility data. The juvenile mortality during summer is calculated by subtracting the number of juveniles surviving to the August census from the estimate of the number born.

1.3.2 Results

1.3.2.1 Jackrabbit Population Counts. Results are a continuation of those reported in Reference 6. For reference purposes the transects are grouped into eight subareas (Appendix Figures C.1 through C.6). As reported in Reference 6, population cycles in the areas west of DPG are in close synchrony with those within DPG. However, cycles in areas east of DPG appear to be one to two years out of phase with populations within the DPG boundaries.

1.3.2.2. Estimates of Fertility and Mortality. The fertility information for all areas was pooled (Appendix Table A.1). All embryos, at all stages of development, were included in the tally. To represent the yearly production of juveniles accurately, the number of nonpregnant females must be considered each month. However, when the number of nonpregnant females is subtracted, the relative fertility from year to year is about the same as when the average number of embryos per the entire female population was considered.

The mean number of embryos each year is presented in Table 1. Generally, decreases occur during periods of high population. Insufficient fertility data were gathered to prepare meaningful averages from 1975 to 1977.

Fertility and mortality vary independently within 10-year cycles (Figure 2). Ten-year periods were duplicated and connected to show the shapes of the respective curves.

Generally, neither fertility nor mortality alone controls the jackrabbit population cycle. When the population was low during 1966 - 1970, the fertility was increasing and the juvenile mortality decreasing. During the population years, 1971 - 1973, the fertility decreases and the juvenile mortality increased. The population crash started in 1973 when the juvenile mortality curve crossed the fertility curve. The crash was intensified by sharply increased winter and summer adult mortalities. The main cause of adult mortality was probably coyote predation, and is most evident during the crash year of 1974. The juvenile mortality rate is always higher than the adult mortality rate (Table 2), and it is probable that population trends are more dependent on juvenile mortality than on adult mortality.

1.3.2.3 Determination of Juvenile Population. The percentages of juveniles in the jackrabbit population are summarized for the years 1975 - 1979 (Table 2); the weight distribution of eye lenses, which increase proportionally in mass with the increased age of juvenile rabbits, are shown in Appendix Figures D.1 through D.5.

Table 1. Annual Mean Fertility Rates Estimated for Blacktailed Jackrabbits from 1965 to 1979 in the Southern Bonneville Basin, Utah (Source: Appendix Table A.1)

Year	Mean Viable Embryos Per Female
1966	3.05 ± 0.64*
1967	3.65 ± 1.20
1968	4.12 ± 0.58
1969	3.71 ± 0.95
1970	3.68 ± 0.70
1971	3.89 ± 0.50
1972	3.19 ± 0.61
1973	3.68 ± 0.86
1974	2.68 ± 1.74
1978	4.75 ± 3.80
1979	3.65 ± 0.29

*95% confidence interval

Table 2. Percentages of Adults and Juveniles in the Population of Blacktailed Jackrabbits Estimated in the Fall

Year	Adults (%)	Juveniles (%)
1975	----*	----
1976	20.5	79.5
1977	----	----
1978	26.1	73.9
1979	32.5	67.5

*Insufficient data collected for the these years.

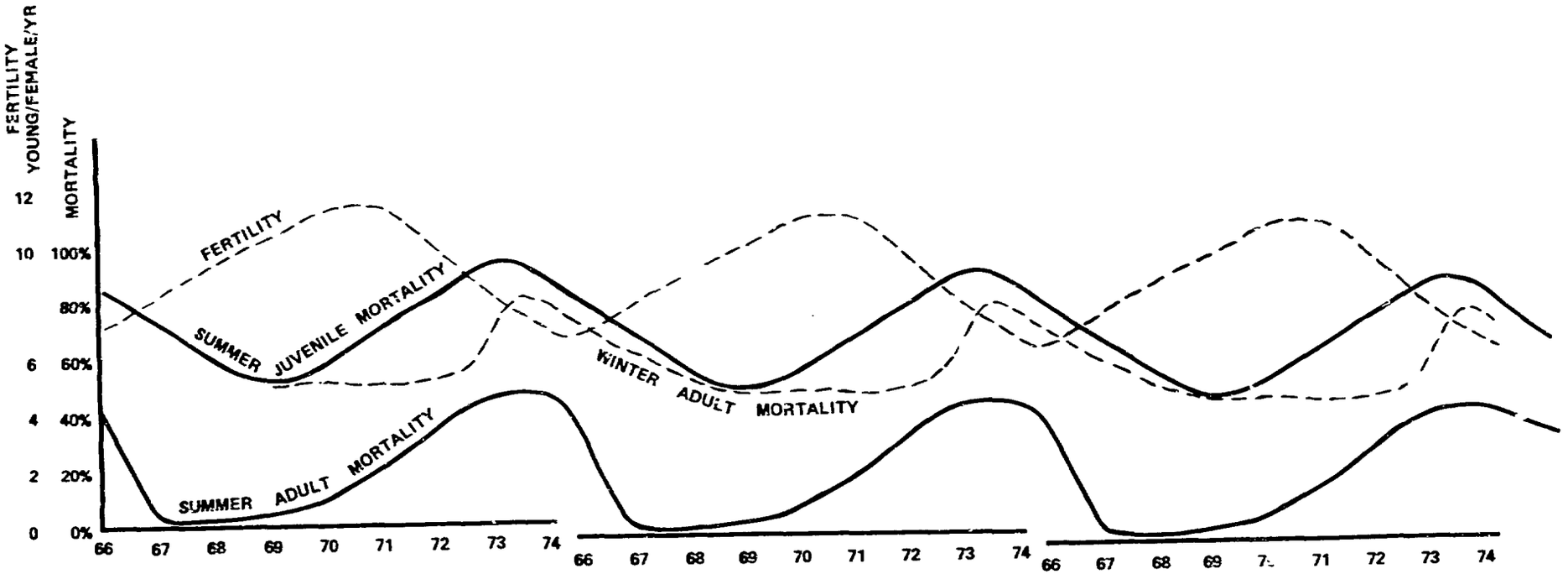

Figure 2 Cyclic Fluctuations in the Mortality and Fertility Base Lines of the Adult and Juvenile Populations of the Blacktailed Jackrabbit, Southern Bonneville Basin, Utah. A single ten-year period has been repeated three times to demonstrate the wave form for fertility, summer mortality of juveniles, and both summer and winter mortalities of adults. Factors most significantly affecting the wave form of the population cycle are the degree of fertility and the amount of juvenile mortality.

SECTION 2. ZOONOTIC INFECTIONS TRANSMISSIBLE TO HUMANS

2.1 BACKGROUND

Surveillance for serological evidence of tularemia in the native fauna and livestock has been continued routinely through this study. Serological examinations for antibodies for the etiologic agents of Q fever and Rocky Mountain spotted fever, bubonic plague, and several of the arthropod-borne encephalitides were done during the earlier years of this program (1950 - 1972). The seemingly small fluctuation in incidences of the latter diseases, the change in direction of the biological program to emphasis on defensive studies, and reduction of the work force contributed to the decision to reduce the scope of the surveillance efforts to their present level. Also, review of the accumulated serological results revealed that realignment of efforts toward the one endemic disease with the greatest fluctuation in incidence (i.e., tularemia) would greatly increase the cost effectiveness of the program without unduly sacrificing the epidemiological goal.

In 1975 agglutination testing for antibodies to *F. tularensis* was altered to use sheep erythrocytes sensitized to lipopolysaccharide of *F. tularensis*. The procedure provides a method for detecting tularemia and other reacting hemagglutinating antibodies (HA), and caused an apparent increase in the percentage of serum samples found "positive". However, no criterion had been established for the degree of positiveness (in a specified serum dilution) that, for each species sampled, represented actual past infection with the disease. This dilemma was not resolved satisfactorily when results of the HA test were compared with those obtained by the conventional, but less sensitive agglutination with killed *F. tularensis* cells. Consequently, the percentages of positive reactors, by species, reported in the triennial period 1974 through 1976 (Reference 6) appear inflated when compared with the results presented in preceding reports.

The problem of interpreting the titer (dilution) that represented past infection with *F. tularensis* for each species tested was resolved in two ways. First, the optimal dilutions of fresh microbial antigens were established by block titration with several serum samples known to possess tularemia antibodies. Then, the optimal dilutions of the antigens were used to reassess all frozen, positive samples collected in 1978 and 1979 and all samples from 1980. Second, all samples found to possess HA and regular agglutinating antibody were grouped by species, and the reciprocals of the highest dilution found to agglutinate the antigen were used to estimate a geometric mean titer for each species.

2.2 OBJECTIVES

a. To examine serum samples collected from rodents, jackrabbits, livestock (sheep and cattle), carnivores, and other species for the presence of antibodies that agglutinate *F. tularensis*. This procedure will allow estimation of the incidence of tularemia in local populations.

b. To develop and refine techniques for accumulating and analyzing serological data.

c. To continue monitoring for evidence of natural zoonotic infections.

d. To maintain liaison and cooperation with farmers and stockmen in the area to permit collecting samples from their livestock, the source of present estimates of some epidemiological baselines.

e. To coordinate activities with public health and state agriculture officials and local mosquito abatement districts.

f. To maintain the technical competence of personnel assigned to the Environmental and Ecology Branch.

2.3 ACCOMPLISHMENTS

The comparisons described in Section 2.1 show that the procedures used yielded geogmetric mean (GM) titers for the HA procedure which were consistently two- to eightfold greater than titers found by agglutinating the microbial suspension (MA). These GM values, in turn, were used to establish tentative criteria for seropositive samples for each species. The respective HA and MA titers chosen were 1:256 and 1:32 for the coyote and other canivores; 1:32 and 1:16 for sheep; 1:64 and 1:32 for the cattle, and 1:80 and 1:40 for the jackrabbit and rodent species.

Only a few of the serum specimens from rodents collected during 1977 and 1978 (the last years they were collected) were positive for tularemia (Table 3). Four of the 16 specimens (25 percent) of the canyon deer mouse (*Peromyscus crinitus*) were found positive in 1977. However, the sample size was too small for tests of statistical significance, and sample volume was insufficient for confirmatory testing. Serum samples were not collected from rodents after CY 1978.

Less than two percent (1.8, 1.5, and 0.7 percent, respectively) of the serum samples collected from jackrabbits in 1977, 1978, and 1979 contained antibodies to tularemia. The jackrabbit is the only remaining sentinel species under surveillance for tularemia antibodies.

The results of surveillance of the sheep populations for the presence of tularemia antibodies, pooled for all collecting sites by season and year, are shown in Table 4. Large differences in the percentages (0 to 50 percent) found positive are seen to occur with time, but cannot be correlated with seasons. Although the reasons for the fluctuation within a given year are unknown, possible explanations include the effect of the seasonal climatic variation on the feeding activity of the insect vectors, difference in numbers of vectors, and the difference in the lethality of the strain of the etiologic agent involved. For a given number of infected animals in a specific species, the lethality of the strain of *F. tularensis* tends to be inversily related to the incidence of tularemia seropositives, i.e., the higher the lethalely,

Table 3. Results of Serological Testing for F. tularensis Antibody in Blacktailed Jackrabbits and Various Species of Rodents.

Species*	1977		1978		1979	
	No. Spec.	% Positive	No. Spec.	% Positive	No. Spec.	% Positive
Whitetailed Antelope Squirrel	35	0	13	0	ND**	ND
Kangaroo rat	172	0	100	0	ND	ND
Kangaroo mouse	21	0	19	0	ND	ND
Woodrat	11	0	ND	ND	ND	ND
Grasshoper mouse	1	0	ND	ND	ND	ND
Deer mouse (*P. crinitus*)	16	25	ND	ND	ND	ND
Pocket mouse (*P. formosus*)	2	0	ND	ND	ND	ND
Deer mouse (*P. maniculatus*)	44	2.3	22	0	ND	ND
Pocket mouse (*P. parvus*)	1	0	ND	ND	ND	ND
Deer mouse (*P. truei*)	3	0	ND	ND	ND	ND
Chipmonk	ND	ND	8	0	ND	ND
Jackrabbit	109	1.8	195	1.5	404	0.7

*For Latin names of these species, See Appendix Table B.
**Not Done.

the fewer the seropositive survivors. However, in resistant animals, especially carnivores and carrion eaters, there may be positive correlation between incidence of tularemia infection in nature and seropositives.

Table 4. Results of Serological Testing for Antibody to *Francisella tularensis* in Sheep and Cattle. Serum Samples Collected during Spring and Fall 1977 through 1979.

	Sample Size		Percent Positive*	
	Sheep	Cattle	Sheep	Cattle
77 - Spring	112	32	23	34
77 - Fall	48	32	2	3
78 - Spring	16	14	0	7
78 - Fall	16	47	50	10
79 - Spring	64	16	15	6
79 - Fall	30	32	0	3

* Hemagglutination criterion for positive tentatively ≥ 1:80, and microagglutination, ≥ 1:40. These values represent one dilution step less than the GM titers estimated from positive samples found.

The serological results for cattle were tabulated in the same way as the results for sheep and showed the same yearly trend of fluctuation in percentages found positive for tularemia (Table 4). The percentages of sheep samples found positive were less overall than those for cattle. As with the serologies for sheep samples, reasons for the degree of fluctuation found for cattle samples are unknown, and the same hypotheses for the variations apply. The fact that the rise and fall of incidence of tularemia positives in cattle parallels that for sheep strongly indicates that inadequate sample size is not a problem.

In contrast to the species already discussed, the reason for the greater percentages of carnivores having antibodies for *F. tularensis* (Table 5) is simple. These scavenging mammals experience little mortality when infected with *F. tularensis* and find animals debilitated by infection to be an easily attainable source of food. The largest number of serum specimens for the coyotes were collected during 1977, 1978, and 1979 and produced positive rates of 22, 14.3 and 48 percent, respectively. Again, the number of specimens collected each year was small; hence, fluctuations in the percentages reported may have a relatively low degree of statistical significance. Efforts

Table 5. Results of F. tularensis Antibody Screening Test on Serum Samples Collected from Carnivores, Mule Deer, and Water Shrew, 1976 through 1980.

Species*	Dec 76 - Feb 77		Oct 77 - Feb 78		Oct 78 - Jan 79		Oct 79 - Feb 80	
	No. Spec.	% Positive	No. Spec.	% Positive	No. Spec.	% Positive	No. Spec.	% Positive
Coyote	9	22	21	14.3	25	48	19	57.9
Kit fox	10	0	14	0	2	0	ND**	ND
Wildcat	3	0	7	0	ND	ND	ND	ND
Badger	3	66.7	1	0	ND	ND	ND	ND
Mule deer	1	0	1	0	ND	ND	ND	ND
Water shrew	ND	ND	1	0	ND	ND	ND	ND

*For Latin names of these species, see Appendix Table B.
**Not done.

directed toward obtaining more samples and greater cost effectiveness have promoted realignment of this collection program. The coyote will become the principal, if not the only, carnivore collected in large numbers.

SECTION 3. ECOLOGICAL TOXICOLOGY

3.1 BACKGROUND

Monitoring for potentially adverse environmental effects of testing with organophosphrus agents will have to be undertaken if and when open-air tests will be resumed. Meanwhile, the toxicological aspect of the program is directed at establishing baseline ranges of erythrocytic acetylcholinesterase (AChE) activity, and at the detection of effects of agricultural employment (if any) of AChE inhibitors (pesticides). Blood samples from wildlife and livestock in the area on and around DPG have been collected, with the primary goal to establish seasonal baselines and maintain records of the levels of AChE activity for several sentinel species. In addition to determining mean levels of AChE activity, efforts have been made to narrow the confidence limits of the data by increasing the number of samples collected per species and refining the assay technique. Narrower limits will improve the ability to detect the presence of cholinesterase-blocking chemicals in the environment.

For the collection program of 1977 through 1979, blood samples from cattle and sheep were collected in the spring and fall. Blood samples from jackrabbits, although collected for serological examination, are no longer examined for levels of AChE activity. The reasons for ending AChE determinations for rabbit and rodent specimens include (1) the existence of sufficient information for establishing a firm baseline (i.e., approximately 500 determinations/species) and (2) the greater ease and economy afforded by selecting larger, more accessible animals (i.e., livestock) for routine surveillance.

3.2 OBJECTIVES

a. To determine baseline levels of AChE activity for jackrabbits, selected rodents, and livestock.

b. To detect effects of the use (if any) of pesticides by farmers/ranchers.

c. To evaluate and improve methods for determining levels of AChE activity.

3.3 ACCOMPLISHMENTS

The analysis of AChE levels (by enzymatic manometry or Warburg apparatus) showed values within the normal ranges for cattle and sheep for the three years (Tables 6 and 7, respectively). Decreased levels of activity were found for some herds, such as sheep from Chalk Valley in 1978 and 1979 (64.8 and 63.9 micromoles/ml of red blood cells/hr, respectively, Table 7). Similar observations were made in past years. These departures from "normal" values were not critical. However, they are significant in terms of the establishment of variations between herds; they are associated with herds from areas distant to the proving ground; and they may be indicative of exposure to AChE - inhibiting pesticides. Values for specimens collected in the fall of 1977

Table 6. Mean Values of Erythrocytic Acetylcholinesterase (AChE) Activity in Blood Samples Collected, 1977 through 1979.

Date	Herd No.	Summer Range	Winter Range	Mean AChE Activity, micromoles/ ml RBCs[a]/hr	Sample Size	Standard Deviation
77 - Spring	28	Callao	Callao	228.4 ±17.4[b]	14	33.2
78 - Fall	28	Callao	Callao	173.4 ±19.3	16	39.5
	None	Unknown	Benmore	216.4 ±16.0	15	31.8
	41	Wasatch Mtn.	Skull Valley	175.3 ±23.9	16	49.1
79 - Fall	28	Callao	Callao	193.1 ±29.0	16	59.1
	30	Vernon	Benmore	192.0 ±12.8	15	25.5

[a]Red blood cells.
[b]95 percent confidence interval.

Table 7. Mean Values of Erythrocytic Acetylcholinesterase (AChE) Activity in Blood Samples Collected from Sheep, 1977 through 1979.

Date	Herd No.	Summer Range	Winter Range	Mean AChE Activity, micromoles/ ml RBCs[a]/hr	Sample Size	Standard Deviation
77 - Spring	1	Bear Lake	Dugway Mtn.	85.5 ±6.0[b]	14	11.5
	2	Bear Lake	Davis Mtn	86.4 ±5.3	14	14.6
	4	Bear Lake	White Rock	88.9 ±7.0	14	13.3
	9	Uinta Mtn.	Aragonite	85.5 ±6.0	14	11.5
	24	Chalk Creek	Callao	91.2 ±10.6	14	20.2
78 - Fall	33	Chalk Creek	W.Dugway Mtn.	64.8 ±8.5	16	17.4
79 - Fall	33	Chalk Creek	Dugway Mtn.	63.9 ±8.4	15	16.6
	None	Strawberry	Erickson Pass	85.0 ±9.9	16	20.4

[a]Red blood cells.
[b]95 percent confidence interval.

and the spring of 1979 are missing because of refrigeration malfunction resulting in loss of specimens.

Assay procedures were not evaluated during this report period.

SECTION 4. IN-HOUSE LABORATORY INDEPENDENT RESEARCH (ILIR), ARBOVIROLOGY

4.1 BACKGROUND

One of the missions assigned to the Environmental and Ecology Branch is surveillance for natural outbreaks of epizootic disease in the area surrounding DPG (Reference 1). Samples of blood collected from livestock and wildlife in the early 1960s contained neutralizing antibodies to the Group A arboviruses. Because these antibodies neutralized Venezuelan equine encephalitis virus (VEE), attempts were made to isolate this virus from mosquitoes and small mammals collected in the vicinity of DPG. These efforts were not successful. However, numerous isolates of California encephalitis (CE) virus were obtained. Again in 1972, the concern of veterinary officials arose that VEE virus might be migrating into Utah from Central America. This led to the decision to include southern Utah in the surveillance study area. Isolation studies of VEE virus from mosquitoes, in cooperation with the Utah State and US Departments of Agriculture, were started. Despite the increased surveillance area, no isolations of VEE virus have been made to date. However, continued isolation of CE virus prompted concentration of most of the available effort (in the last few years) to the study of the epidemiology of CE virus and to finding the particular conditions that maintain its endemic cycles in western Utah.

4.2 OBJECTIVES

From 1977 through 1979, studies were directed toward obtaining a better understanding of the natural chain of infection for CE virus. Other objectives include continuing the liaison developed with state and federal human and animal health agencies.

4.3 ACCOMPLISHMENTS

A joint study with Utah State Department [illegible]ealth was begun to detect possible human exposure to CE virus in weste[illegible]. Blood samples were collected from natives attending the West Des[illegible] at Callao, Utah in 1976 and subsequently tested by three serologic[illegible]. The percentages of individuals possessing neutralizing antibody ag[illegible] a local strain of CE virus was surprisingly large (50 percent).

Finding the large percentage of inhabitants with neutralizing antibody to CE virus prompted a study to attempt to identify the animal host that permitted the CE virus to overwinter in the affected area. Because the cottontail (*Sylvilagus audobonii*) and jackrabbit are abundant in the area, blood samples were collected from these species in the Fish Springs/Blue Lake areas of western Utah. The results of tests on 94 blood samples collected in 1978 showed that 53 (56 percent) had significant levels of neutralizing antibodies against CE virus. A comparison of these serological data with previous results for isolations of CE virus from mosquitoes revealed that the Blue Lake

area had the higher incidence of neutralizing antibody in jackrabbits and that CE virus exists in the mosquito population of the area.

Scientific publications and oral presentations about these studies are listed in Appendix E.

SECTION 5. IN-HOUSE LABORATORY INDEPENDENT RESEARCH (ILIR), POPULATION BIOLOGY OF LAGOMORPHS

5.1 BACKGROUND

In the study of the dynamics of jackrabbit population on and near DPG, considerable quantities of data have been obtained. This information is suitable for analysis by automated data processing to provide an unmatched analysis of factors and interactions which affected the lagomorphs, and which determined fluctuations in population structure, density, fertility and mortality. Procedures for automated processing of these data also will have direct application to on-going ecological studies. Results from this study will be of general scientific interest and may serve as a model for similar environmental investigations at DPG and other locations.

5.2 OBJECTIVE

To create a more useful and accessible record of historical data collected during the surveillance of jackrabbits since inception of the study in 1952. (This species was selected to monitor the potential for environmental effects of testing activities at DPG, Utah.)

5.3 ACCOMPLISHMENTS

All available DPG data collected to date have been entered into the computer system. Programs have been written and analyses are being performed. Baseline curves have been prepared to show the patterns of fluctuation in total population, fertility, and juvenile and adult mortalities over the years. Population counts have been subjected to dendrogram analysis by computer, and the area relationships have been studied. Plans include preparing manuscripts for publication in appropriate professional journals, plus performing additional analyses for data collected during FY80.

APPENDIX A

ESTIMATE OF POOLED FERTILITY IN BLACKTAILED JACKRABBITS IN THE SOUTHERN BONNEVILLE BASIN, UTAH, 1965 THROUGH 1979

Table A.1. Annual Estimate of Pooled Fertility in Blacktailed Jackrabbits in the Southern Bonneville Basin, Utah, 1965 through 1979.

Conception Date (Julian)	Viable Embryos/ Preg. Female Mean	CI	Resorbed/ Pregnant Female	Females Pregnant No.	Pct.	CR %	Nonpregnant No.	Pct.	Recent Birth No.	Pregnancy Unknown No.	Pct.	Embryos Not Recorded No.	Pct.
1965													
1 - 30	1.26	0.47	0.14	42	79.2	10.9	8	15.1	0	3	5.7	0	0.0
31 - 60	3.69	0.52	0.57	35	74.5	12.5	0	0.0	11	12	25.5	0	0.0
61 - 90	2.20	1.36	0.60	5	38.5	26.4	0	0.0	6	8	61.5	0	0.0
91 - 120	3.88	0.48	0.60	18	66.7	17.8	0	0.0	4	9	33.3	1	3.7
121 - 150	2.29	1.38	0.14	7	38.9	22.5	0	0.0	1	11	61.1	0	0.0
151 - 180	2.40	.68	0.00	6	54.5	29.4	0	0.0	1	5	45.5	1	9.1
181 - 210	0.00	0.00	0.00	0	0.0	0.0	22	100.0	0	0	0.0	0	0.0
Mean	2.45	0.77	0.24	18.8	58.7	19.9			3.8	8.0	38.8		
1966													
1 - 30	1.08	0.27	0.26	31	53.4	12.9	22	37.9	0	5	8.6	0	0.0
31 - 60	2.50	1.20	1.25	12	57.1	21.2	0	0.0	3	9	42.9	0	0.0
61 - 90	4.02	0.59	1.53	80	96.4	4.0	0	0.0	0	3	3.6	0	0.0
91 - 120	4.56	0.54	0.03	35	53.8	12.1	0	0.0	16	30	46.2	0	0.0
121 - 150	2.09	1.24	0.00	5	20.8	16.2	10	41.7	0	9	37.5	0	0.0
151 - 180	0.00	0.00	0.00	0	0.0	0.0	9	100.0	0	0	0.0	0	0.0
181 - 210	0.00	0.00	0.00	0	0.0	0.0	6	100.0	0	0	0.0	0	0.0
Mean	3.05	0.64	0.62	32.6	56.4	13.3			3.8	11.2	27.8		
1967													
1 - 30	1.67	0.95	0.42	13	38.2	16.3	21	61.8	0	0	0.0	1	2.9
31 - 60	2.50	1.13	0.08	12	85.7	18.3	0	0.0	0	2	14.3	0	0.0
61 - 90	4.67	2.87	0.00	4	66.7	37.7	0	0.0	2	2	33.3	1	16.7
91 - 120	5.13	0.70	0.00	16	100.0	0.0	0	0.0	0	0	0.0	0	0.0
121 - 150	4.27	0.80	0.00	15	93.8	11.9	0	0.0	0	1	6.3	0	0.0
151 - 180	3.64	0.75	0.00	11	84.6	19.6	0	0.0	0	2	15.4	0	0.0
181 - 210	0.00	0.00	0.00	0	0.0	0.0	7	100.0	0	0	0.0	0	0.0
Mean	3.65	1.200	0.62	12.0	78.2	17.3			0.3	1.2	11.6		
1968													
1 - 30	1.10	0.23	0.00	10	38.5	10.7	9	34.6	0	7	26.9	0	0.0
31 - 60	4.47	0.93	0.18	17	89.5	13.8	1	5.3	0	1	5.3	0	0.0
61 - 90	5.31	0.67	0.00	13	52.0	19.6	0	0.0	10	12	48.0	0	0.0
91 - 120	5.41	0.47	0.05	37	90.2	9.1	0	0.0	3	4	9.8	0	0.0
121 - 150	4.33	5.74	0.00	4	40.0	30.4	1	10.0	5	5	50.0	1	10.0
151 - 180	4.00	0.00	0.00	1	10.0	18.6	9	90.0	0	0	0.0	0	0.0
181 - 210	0.00	0.00	0.00	0	0.0	0.0	2	100.0	0	0	0.0	0	0.0
Mean	4.12	0.58	0.05	16.2	62.0	18.3			3.6	5.0	28.0		

Table A.1. Annual Estimate of Pooled Fertility in Blacktailed Jackrabbits in the Southern Bonneville Basin, Utah, 1965 through 1979 (cont'd)

Conception Date (Julian)	Viable Embryos/ Preg. Female Mean	CI	Resorbed/ Pregnant Female	Females: Pregnant No.	Pct.	CV %	Nonpregnant No.	Pct.	Recent Birth No.	Pregnancy Unknown No.	Pct.	Embryos Not Recorded No.	Pct.
1969													
0 - 30	1.60	0.29	0.03	30	69.8	13.7	12	27.9	0	1	2.3	0	0.0
30 - 60	4.35	0.52	0.26	23	74.2	15.4	1	3.2	5	7	22.6	0	0.0
60 - 90	5.50	1.03	0.50	18	85.7	15.0	0	0.0	3	3	14.3	0	0.0
90 - 120	5.23	1.08	0.00	13	72.2	20.7	0	0.0	3	5	27.8	0	0.0
120 - 150	3.57	1.84	0.71	7	70.0	28.4	0	0.0	3	3	30.0	0	0.0
150 - 180	2.00	25.41	0.00	2	9.5	12.6	0	42.9	3	10	47.6	0	0.0
180 - 210	2.00	0.00	0.00	1	5.3	10.0	18	94.7	0	0	0.0	0	0.0
Mean	3.71	0.95	0.25	15.5	63.6	17.6			2.8	4.8	24.1		
1970													
0 - 30	1.27	0.22	0.06	33	78.6	12.4	5	11.9	0	4	9.5	0	0.0
30 - 60	4.46	0.62	0.04	24	77.4	14.7	0	0.0	4	7	22.6	0	0.0
60 - 90	5.59	0.52	0.00	22	95.7	8.3	0	0.0	0	1	4.3	0	0.0
90 - 120	3.69	0.80	0.00	13	72.2	20.7	0	0.0	4	5	27.8	0	0.0
120 - 150	3.38	1.34	0.38	8	53.3	25.2	2	13.3	4	5	33.3	0	0.0
150 - 180	2.00	0.70	0.00	2	15.4	19.6	11	84.6	0	0	0.0	1	7.7
180 - 210	0.00	0.00	0.00	0	0.0	0.0	12	100.0	0	0	0.0	0	0.0
Mean	3.68	0.79	0.10	20.0	75.4	16.3			2.4	4.4	19.5		
1971													
0 - 30	1.54	0.24	0.04	27	42.9	12.2	36	57.1	0	0	0.0	1	1.6
30 - 60	4.25	0.57	0.04	29	87.9	11.1	0	0.0	0	4	12.1	1	3.0
60 - 90	5.24	0.72	0.06	17	77.3	17.5	1	4.5	5	4	18.2	0	0.0
90 - 120	4.17	0.38	0.03	36	83.7	11.0	0	0.0	7	7	16.3	1	2.3
120 - 150	4.20	0.60	0.00	15	57.7	19.0	2	7.7	5	9	34.6	0	0.0
150 - 180	4.00	0.00	0.00	1	11.1	20.5	2	22.2	2	6	66.7	0	0.0
180 - 210	0.00	0.00	0.00	0	0.0	0.0	7	100.0	1	0	0.0	0	0.0
Mean	3.89	0.50	0.03	24.8	69.9	14.2			3.2	6.0	24.7		
1972													
0 - 30	1.43	0.25	0.02	44	80.0	10.6	11	20.0	0	0	0.0	0	0.0
30 - 60	3.66	0.51	0.04	47	71.2	10.9	1	1.5	13	18	27.3	0	0.0
60 - 90	3.67	0.72	0.00	15	88.2	15.3	0	0.0	0	2	11.8	0	0.0
90 - 120	4.00	0.94	0.00	10	33.3	16.9	1	3.3	10	19	63.3	1	3.3
120 - 150	0.00	0.00	0.00	0	0.0	0.0	7	77.8	0	0	0.0	2	22.2
150 - 180	0.00	0.00	0.00	0	0.0	0.0	27	96.4	0	0	0.0	1	3.6
180 - 210	0.00	0.00	0.00	0	0.0	0.0	18	100.0	0	0	0.0	0	0.0
Mean	3.19	0.61	0.01	29.0	68.2	13.5			5.8	9.8	25.6		

Table A.1. Annual Estimate of Pooled Fertility in Blacktailed Jackrabbits in Southern Bonneville Basin, Utah, 1965 through 1979 (cont'd)

Conception Date (Julian)	Viable Embryos/Preg. Female Mean	Viable Embryos/Preg. Female CI	Resorbed/Pregnant Female	Females Pregnant No.	Females Pregnant Pct.	Females Pregnant CI[a] %	Females Nonpregnant No.	Females Nonpregnant Pct.	Recent Birth No.	Pregnancy Unknown No.	Pregnancy Unknown Pct.	Embryos Not Recorded No.	Embryos Not Recorded Pct.
[illegible]													
0 - 30	2.00	0.88	0.00	5	23.8	18.2	16	76.2	0	0	0.0	0	0.0
30 - 60	3.25	1.40	0.00	8	100.0	0.0	0	0.0	0	0	0.0	0	0.0
60 - 90	5.33	1.02	0.00	9	90.0	18.6	0	0.0	0	1	10.0	0	0.0
90 - 120	4.79	0.99	0.00	19	67.9	17.3	0	0.0	0	9	32.1	0	0.0
120 - 150	3.00	0.00	0.00	1	50.0	69.3	0	0.0	0	1	50.0	0	0.0
150 - 180	0.00	0.00	0.00	0	0.0	0.0	0	0.0	0	0	0.0	0	0.0
180 - 210	0.00	0.00	0.00	0	0.0	0.0	9	100.0	0	0	0.0	0	0.0
Mean	2.68	0.86	0.00	8.4	66.3	24.7			0.0	2.2	18.4		
1974													
0 - 30	1.20	0.56	0.00	5	33.3	23.9	10	66.7	0	0	0.0	0	0.0
30 - 60	2.50	6.35	0.00	2	50.0	49.0	0	0.0	0	2	50.0	0	0.0
60 - 90	4.20	0.66	0.00	10	100.0	0.0	0	0.0	0	0	0.0	0	0.0
90 - 120	[illegible]	[illegible]	0.00	10	71.4	23.7	0	0.0	0	4	28.6	0	0.0
120 - 150	2.00	[illegible]	0.00	1	10.0	18.6	1	10.0	0	8	80.0	0	0.0
150 - 180	0.00	0.00	0.00	0	0.0	0.0	2	100.0	0	0	0.0	0	0.0
180 - 210	1.00	0.00	0.00	1	16.7	29.8	5	83.3	0	0	0.0	0	0.0
Mean	2.86	1.74	0.00	5.6	52.9	23.0			0.0	2.8	3[illegible]		
[illegible]													
0 - 30	1.38	0.43	0.00	8	53.3	25.2	7	46.7	0	0	0.0	0	0.0
30 - 60	2.13	0.94	0.13	8	100.0	0.0	0	0.0	0	0	0.0	0	0.0
60 - 90	4.33	1.43	0.00	3	100.0	0.0	0	0.0	0	0	0.0	0	0.0
90 - 120	1.00	0.00	0.00	1	25.0	42.4	1	25.0	0	2	50.0	0	0.0
120 - 150	3.00	4.30	0.00	3	60.0	42.9	0	0.0	0	2	40.0	0	0.0
150 - 180	0.00	0.00	0.00	0	0.0	0.0	0	0.0	0	0	0.0	0	0.0
180 - 210	3.00	0.00	0.00	1	20.0	35.1	3	60.0	0	1	20.0	0	0.0
Mean	2.81	1.78	0.02	3.4	51.2	20.8			0.0	0.7	15.7		
[illegible]													
0 - 30	1.25	0.80	0.00	4	57.1	36.7	3	42.9	0	0	0.0	0	0.0
30 - 60	5.00	12.71	0.00	2	50.0	49.0	0	0.0	2	2	50.0	0	0.0
60 - 90	6.25	1.40	0.00	8	80.0	24.8	0	0.0	0	2	20.0	0	0.0
90 - 120	5.40	1.11	0.00	5	45.5	29.4	0	0.0	4	6	54.5	0	0.0
120 - 150	0.00	0.00	0.00	0	0.0	0.0	0	0.0	0	0	0.0	0	0.0
150 - 180	0.00	0.00	0.00	0	0.0	0.0	2	100.0	0	0	0.0	0	0.0
180 - 210	0.00	0.00	0.00	0	0.0	0.0	0	0.0	0	0	0.0	0	0.0
Mean	2.70	2.29	0.00	2.7	33.2	20.0			0.8	1.4	17.7		

Table A.1. Annual Estimate of Pooled Fertility in Blacktailed Jackrabbits in the Southern Bonneville Basin, Utah, 1965 through 1979 (cont'd)

1979 Conception Date (Julian)	Viable Embryos/ Preg. Female		Resorbed/ Pregnant Female	Females					Recent Birth	Pregnancy Unknown		Embryos Not Recorded	
				Pregnant			Nonepregnant						
	Mean	CI[a]		No.	Pct.	CI ±	No.	Pct.	No.	No.	Pct.	No.	Pct.
0 - 30	1.09	0.10	0.18	114	93.4	4.4	6	4.9	0	2	1.6	0	0.0
30 - 60	2.30	0.44	0.20	40	64.5	11.9	6	9.7	0	16	25.8	0	0.0
60 - 90	5.13	0.51	0.00	16	100.0	0.0	0	0.0	0	0	0.0	0	0.0
90 - 120	5.40	0.31	0.10	104	86.7	6.1	2	1.7	12	14	11.7	0	0.0
120 - 150	4.33	0.54	0.00	18	42.9	15.0	0	0.0	22	24	57.1	0	0.0
150 - 180	0.00	0.00	0.00	0	0.0	0.0	0	0.0	8	14	100.0	0	0.0
180 - 210	0.00	0.00	0.00	0	0.0	0.0	72	97.3	8	2	2.7	0	0.0
Mean	2.61	0.27	0.07	41.7	55.4	5.3			5.4	10.3	28.4		

a. CI, Confidence interval.
* Inadequate collections made in 1975 and 1976 precluded calculating values.

APPENDIX B

SCIENTIFIC NAMES

Table B.1. Species List for This Document Used in Text and Tables.

Common Name	Genus and Species
Coyote	*Canis latrans*
Kit Fox	*Vulpes marcotis*
Wildcat	*Lynx rufus*
Badger	*Taxidea taxus*
Mule Deer	*Odocoileus hemionus*
Water Shrew	*Sorex palvstris*
Whitetailed Antelope Squirrel	*Ammospermophilus leucurus*
Kangaroo Rat	*Dipodomys ordii*
Kangaroo Mouse	*Dipodomys microps*
Woodrat or Packrat	*Neotoma lepida*
Grasshopper Mouse	*Onychomys leucogaster*
White-footed or Deer Mouse	*Peromyscus crinitus* *Peromyscus maniculatus* *Peromyscus truei*
Pocket Mouse	*Perognathus formosus* *Perognathus parvus*
Chipmunk	*Eutamias minimus*
Blacktailed Jackrabbit	*Lepus californicus*
Desert Cottontail	*Sylvilagus audobonii*

APPENDIX C

COMPARISON OF SEMIANNUAL INDICES OF BLACKTAILED JACKRABBIT POPULATION DENSITIES BY LOCATION SURVEYED

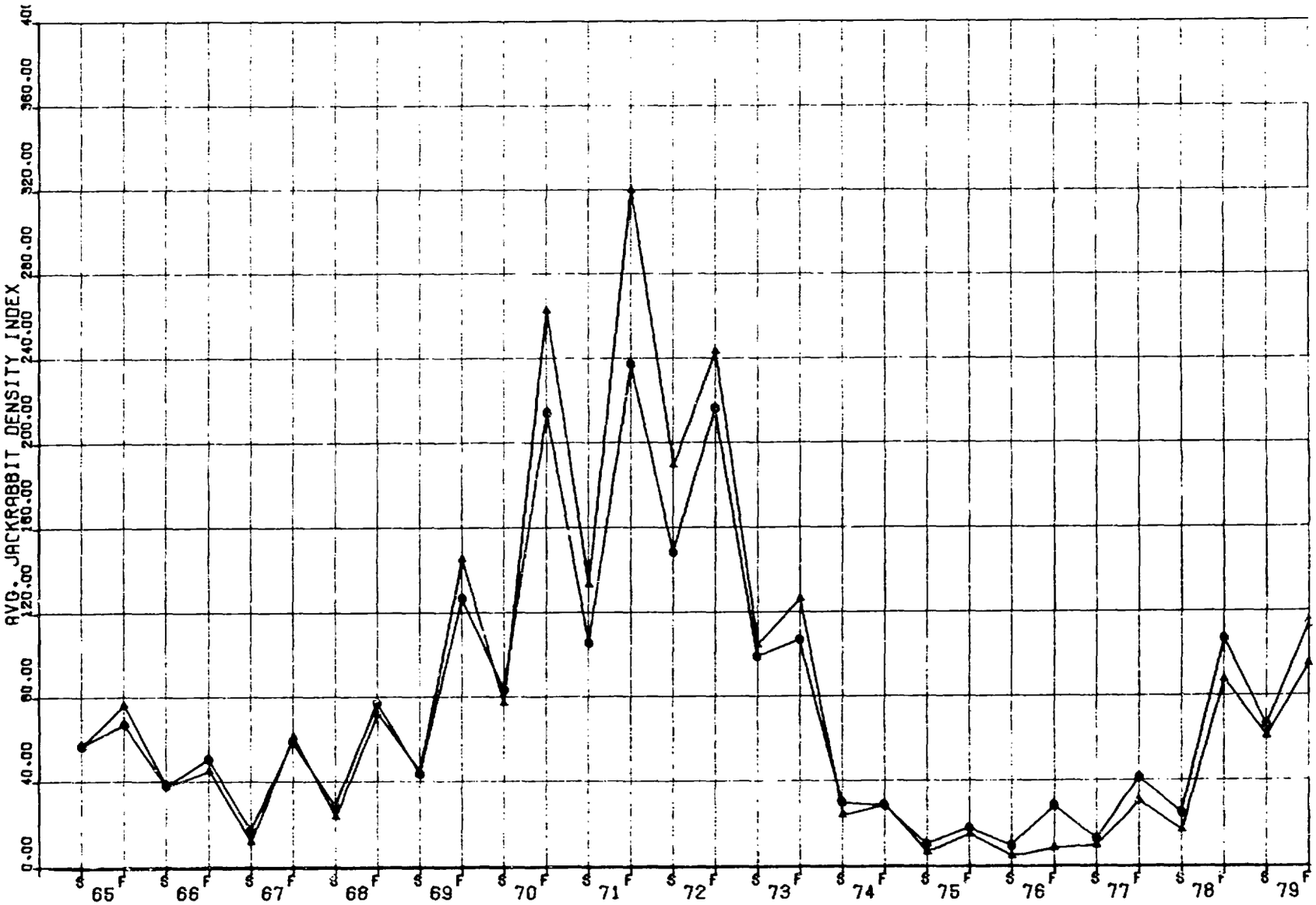

Figure C.1 Comparison of Semiannual Indices of Blacktailed Jackrabbit Densities in Dugway, Utah Area (55 Transect Mean) with the Indices for All 119 Transects taken from the Southern Bonneville Basin, Utah. S, Spring; F, Fall; ▲, Dugway area; ●, All Areas.

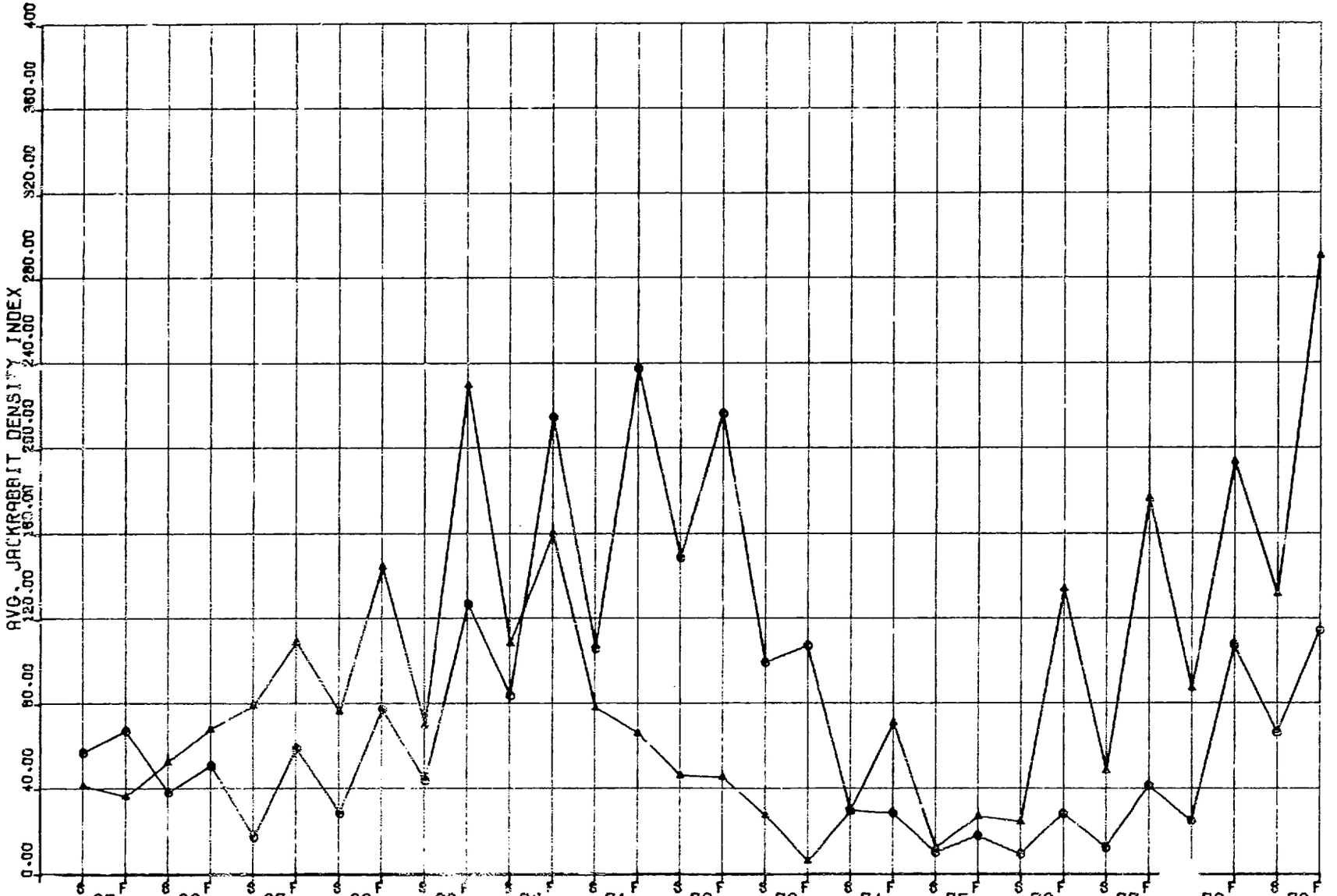

Figure C.2 Comparison of Semiannual Indices of Blacktailed Jackrabbit Densities in Rush Valley, Utah Area (8 Transect Mean) with the Indices for All 119 Transects taken from the Southern Bonneville Basin, Utah. S, Spring; F, Fall; ▲, Rush Valley; ●, All Areas.

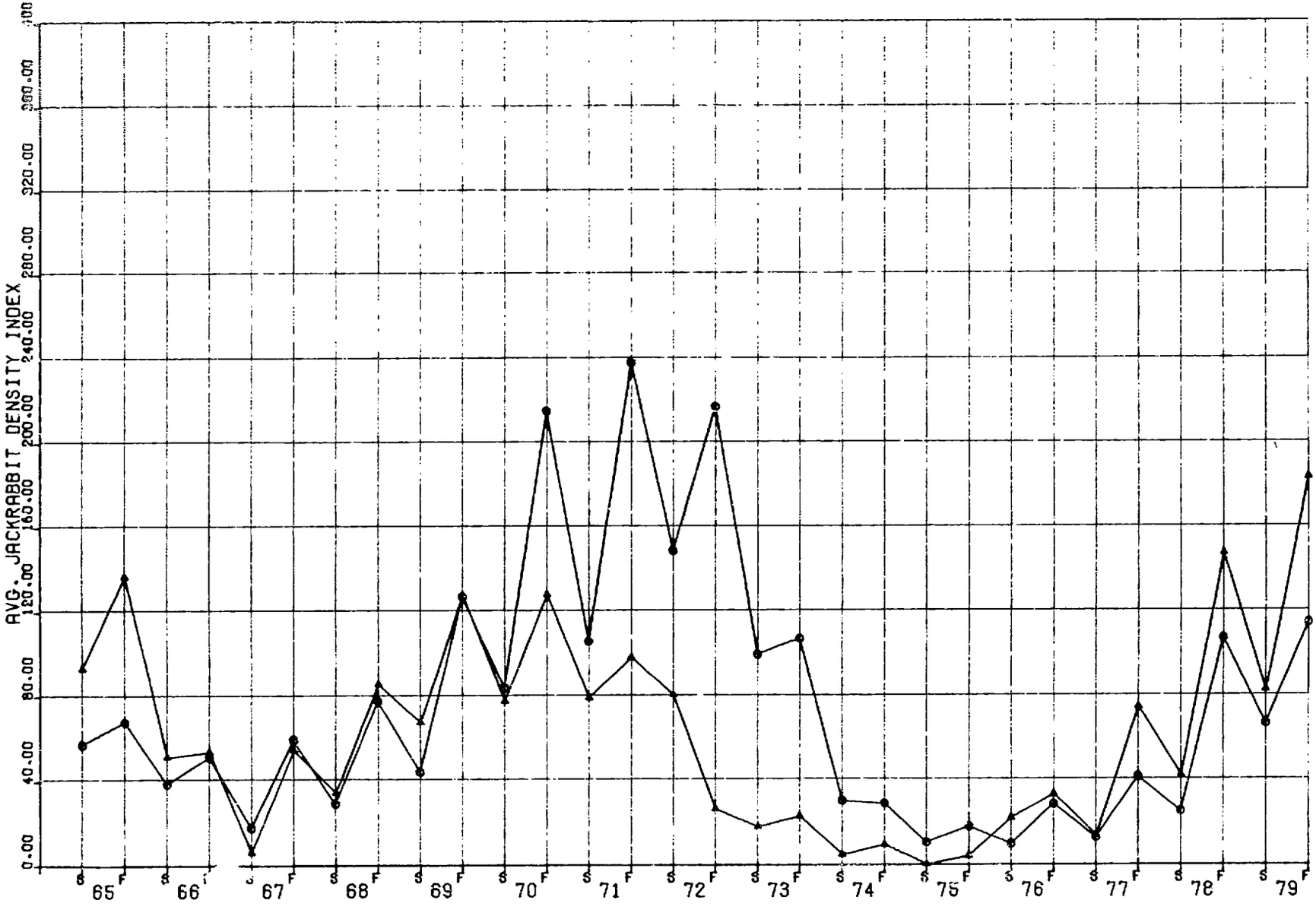

Figure C.3 Comparison of Semiannual Indices of Blacktailed Jackrabbit Densities in North Skull Valley/Lakeside, Utah Area (9 Transect Mean) with the Indices for All 119 Transects taken from the Southern Bonneville Basin, Utah. S, Spring; F, Fall; ▲, No. Skull Valley/Lakeside; ●, All Areas.

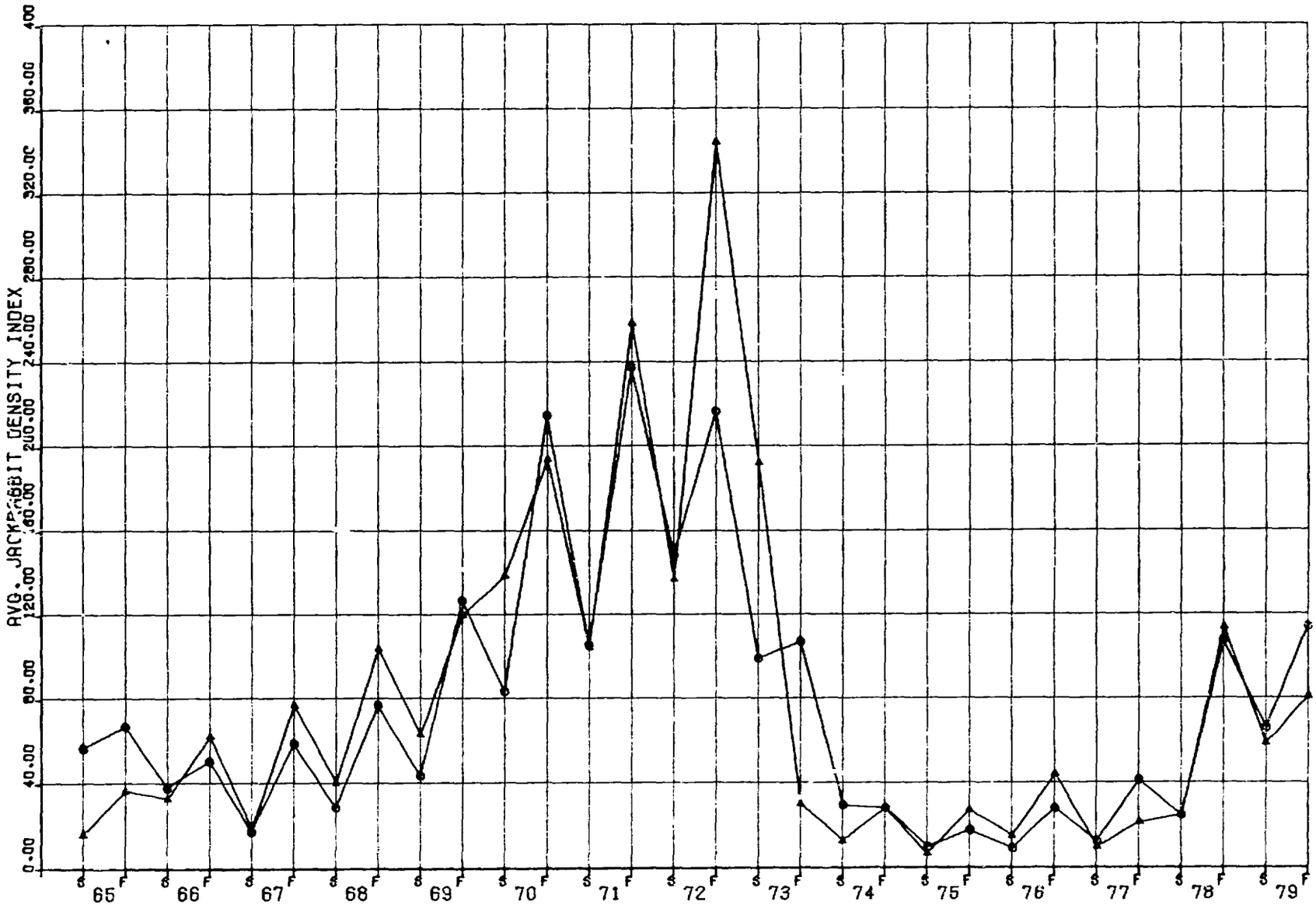

Figure C.4 Comparison of Semiannual Indices of Blacktailed Jackrabbit Densities in Callao, Utah Area (23 Transect Mean) with the Indices for all 119 Transects taken from the Southern Bonneville Basin, Utah. S, Spring; F, Fall; ▲, Callao Area; o, All Areas.

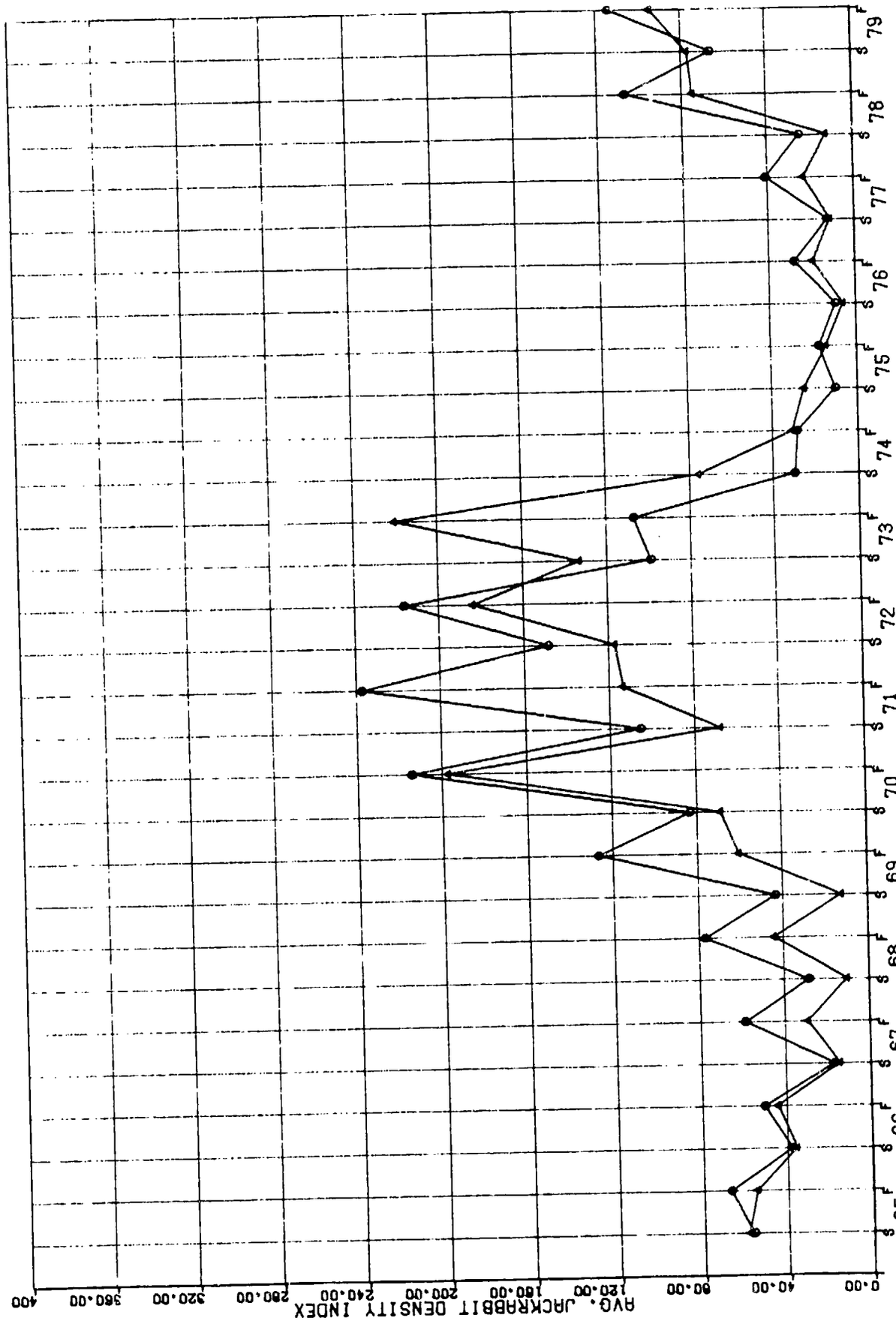

Figure C.5 Comparison of Semiannual Indices of Blacktailed Jackrabbit Densities in Ibapah/Blue Lake, Utah Area (12 Transect Mean) with the Indices for all 119 Transects taken from the Southern Bonneville Basin, Utah. S, Spring; F, Fall; ▲, Blue Lake/Ibapah Area; ●, All Areas.

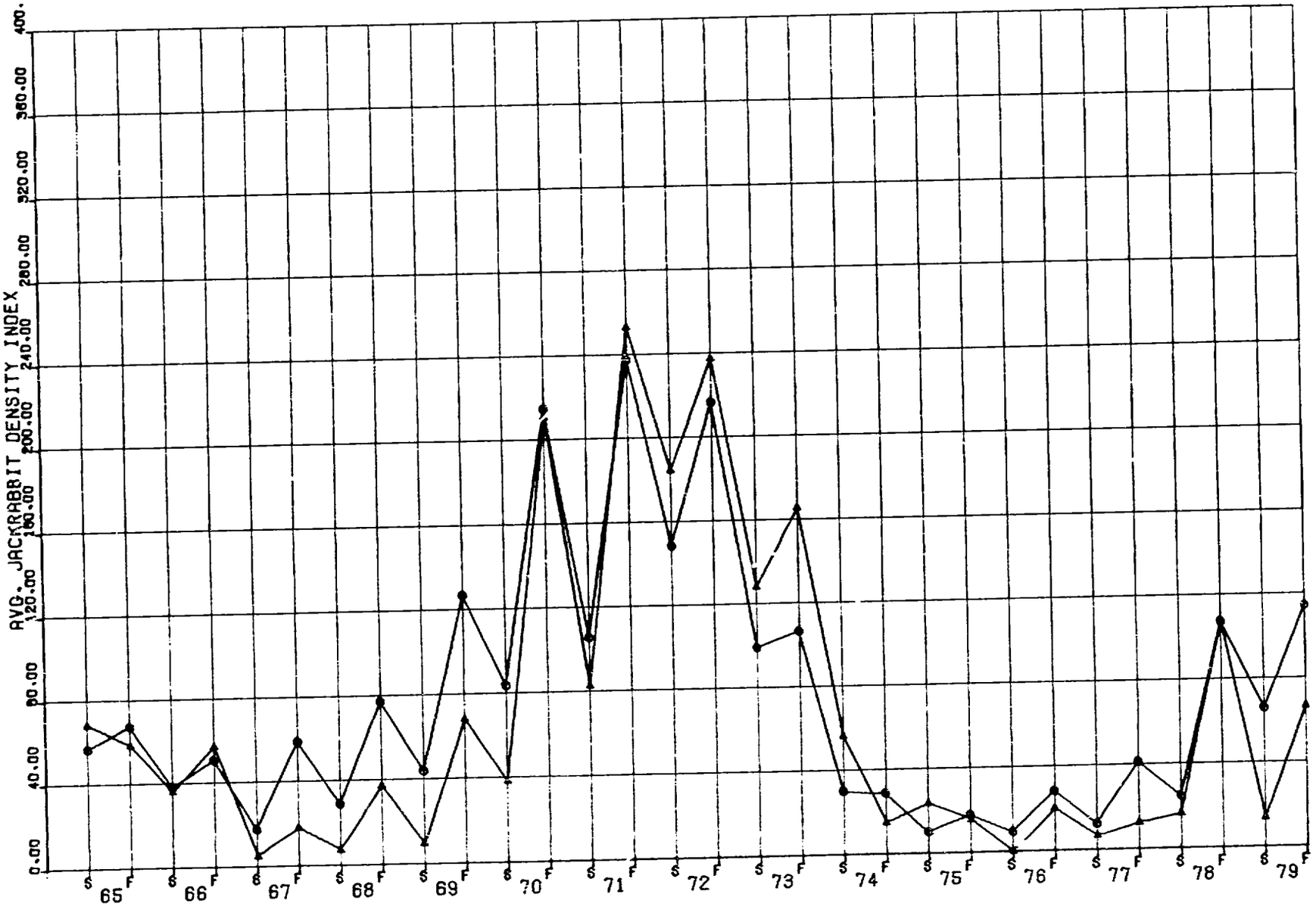

Figure C.6 Comparison of Semiannual Indices of Blacktailed Jackrabbit Densities in Wendover, Utah Area (12 Transect Mean) with the Indices for all 119 Transects taken from the Southern Bonneville Basin, Utah. S, Spring; F, Fall; ▲, Wendover Area; ●, All Areas.

APPENDIX D

DISTRIBUTION OF JACKRABBIT EYE LENS WEIGHTS

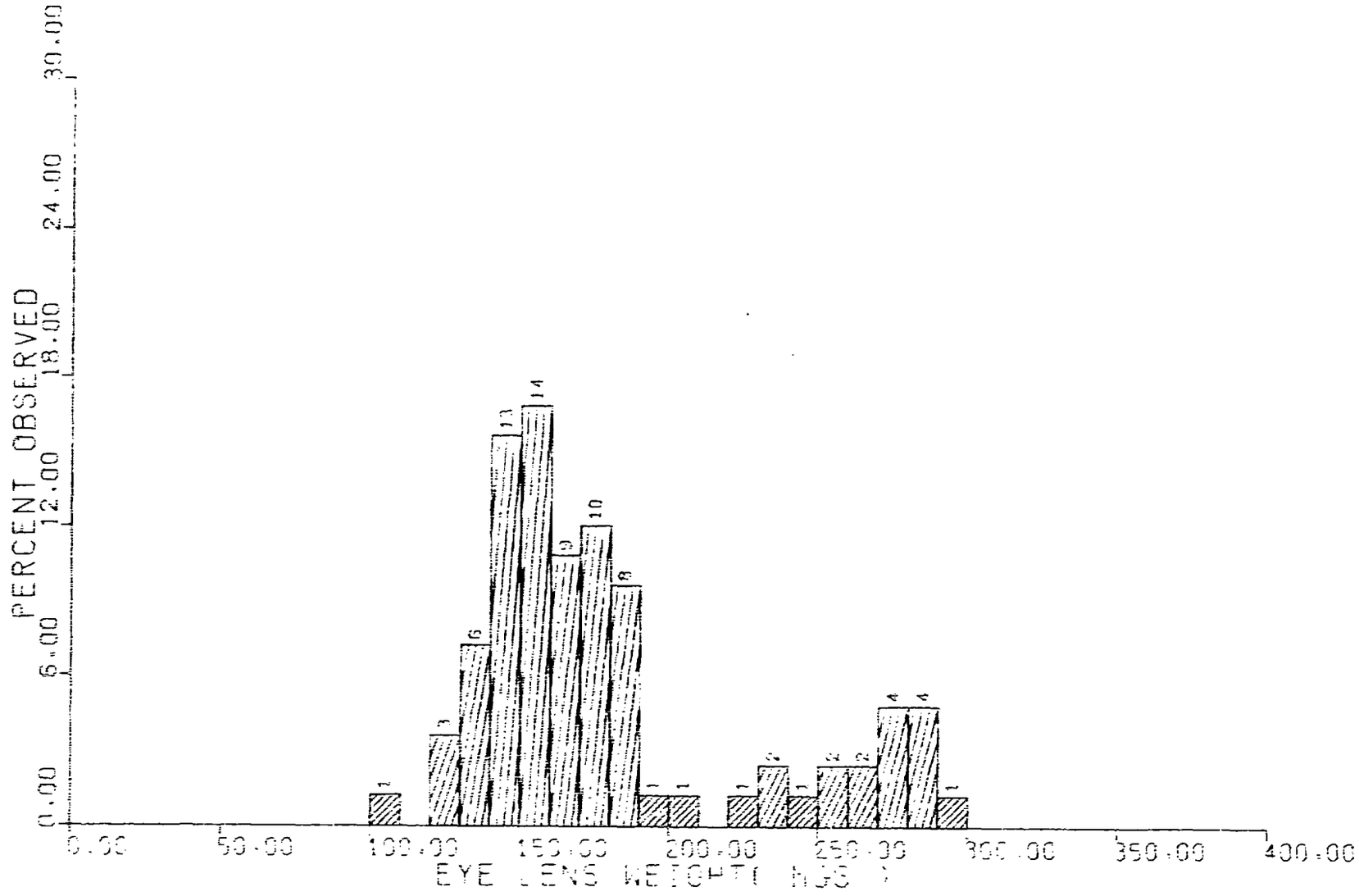

Figure D.1 Distribution of Eye Lens Weights, in mg, for Blacktailed Jackrabbits Collected from August 15th to October 15th, 1976. The number of juveniles in the population is depicted by the peak numbers shown at the left and represents a ratio of 3.88 juveniles to one adult or 80 percent of the total number collected (83).

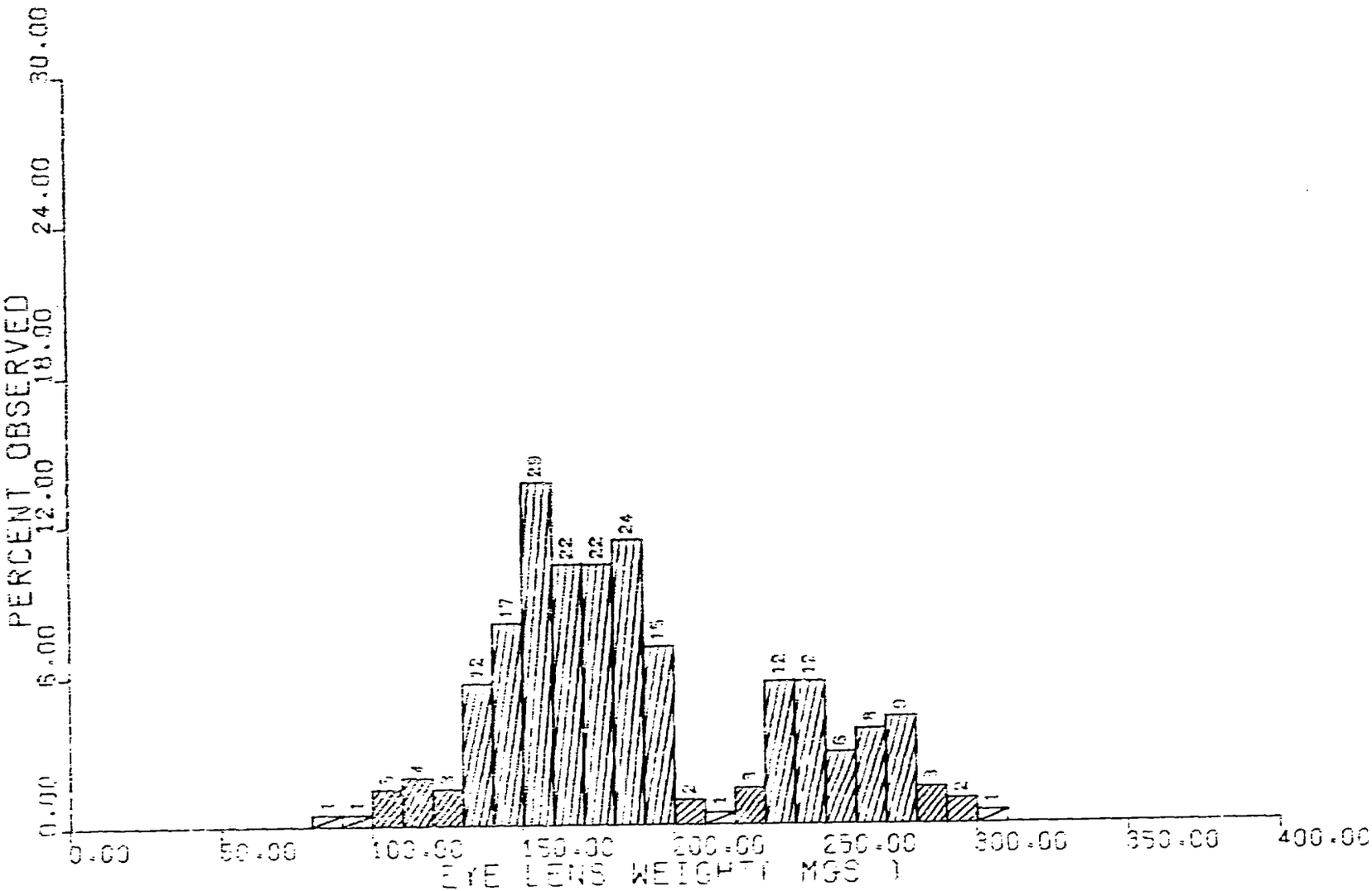

Figure D.2 Distribution of Eye Lens Weights, in mg, for Blacktailed Jackrabbits Collected from August 16th to October 16th, 1978. The number of juveniles in the population is depicted by the peak numbers shown at the left and represents a ratio of 2.75 juveniles to one adult or 73 percent of the total number collected (212).

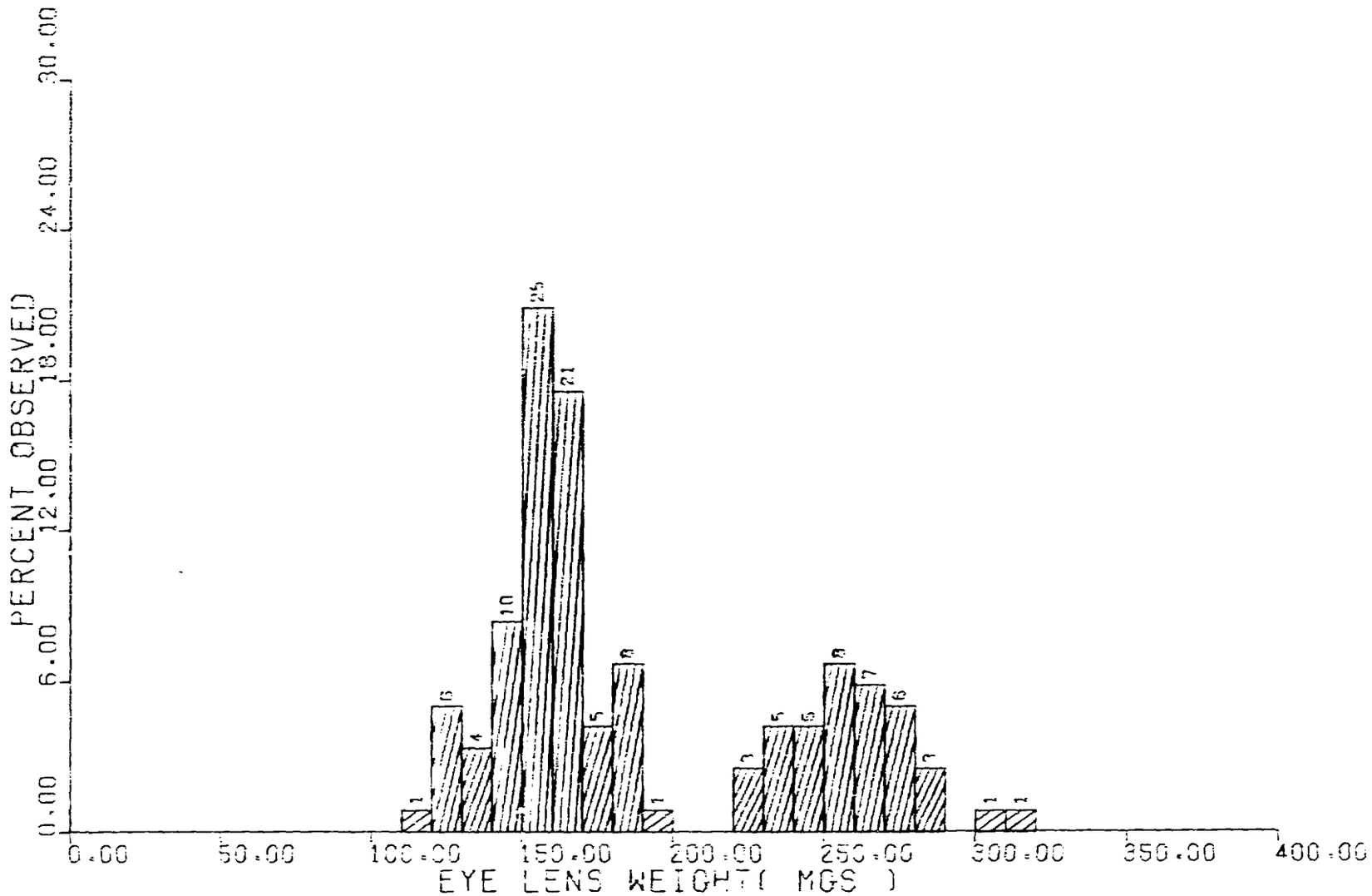

Figure D.3 Distribution of Eye Lens Weights, in mg, for Blacktailed Jackrabbits Collected from August 16th to October 16th, 1979. The number of juveniles in the population is depicted by the peak numbers shown at the left and represents a ratio of 2.08 juveniles to one adult or 68 percent of the total number collected (120).

APPENDIX E

ILIR ARBOVIROLGY - ORAL PRESENTATIONS AND SCIENTIFIC PUBLICATIONS, 1977-1979

A. Oral Presentations

1. International Northwest Conference on Diseases in Nature Communicable to Man (INCDNCM). 32nd Ann. Mtg., Yellow Bay, MT, 15-17 Aug 1977:

a. Western Utah arbovirus isolations, 1967-1971. George T. Crane, Robert E. Elbel, and Charles H. Calisher.

b. Arbovirus isolations from Fish Springs, Callao, and Blue Lake, Utah, 1972-1976. Robert E. Elbel and George T. Crane.

c. Serological evidence for California encephalitis in human inhabitants of western Utah. George T. Crane, J. Clifton Spendlove, Tairo Fukushima, and Douglas W. Hill.

2. INCDNCM, 34th Ann. Mtg., Port Tounsend, WA., 19-22 Aug 1979. Lagomorphs as potential hosts of California encephalitis virus in western Utah. George T. Crane and J. Clifton Spendlove.

3. 16th Annual Conference Northwest Mosquito and Vector Control Association, Corvallis, OR, 5-7 Oct 1976:

a. Isolation of western encephalitis virus from southern Utah *Culex tarsalis*. Robert E. Elbel and George T. Crane.

b. California group virus from *Aedes dorsalis* adults reared from larva collected at Blue Lake, Utah. George T. Crane and Robert E. Elbel.

4. 32nd Annual Meeting of Utah Mosquito Abatement Association, Salt Lake City, Utah. 15 Oct 1979. Serological evidence for California encephalitis in western Utah lagomorphs. George T. Crane and J. Clifton Spendlove.

B. Manuscripts in Preparation for Open Literature Publications

1. Calisher, Charles H., John S. Lazuick, David J. Muth, Oscar de Souza Lopes, George T. Crane, Robert E. Elbel, and Robert E. Shope. Antigenic relationships among Tacaiuma complex viruses of the Anopheles A serogroup (Bunyaviridae).

2. Crane, George T., Robert E. Elbel, D. Bruce Francy, and Charles H. Calisher. California and Bunyamwera Group viruses in western Utah mosquitoes, 1967-1971.

3. Elbel, Robert E.., George T. Crane, D. Bruce Francy, and Charles H. Calisher. Arboviruses and mosquite-midge feeding patterns from western Utah.

C. Published in Open Literature:

1. Crane, George T., Robert E. Elbel, and Charles H. Calisher, 1977. Transovarial transmission of California encephalitis virus in the mosquito *Aedes dorsalis* at Blue Lake, Utah. Mosq. News 37:479-482.

2. Elbel, Robert E., George T. Crane, and Charles H. Calisher, 1977. Arbovirus isolations from southwestern Utah and northwestern Arizona insects. 1972-1975. Mosq. News 37:497-507.

3. Crane, George T. and Robert E. Elbel, 1977. California encephalitis virus at Blue Lake, Tooele County, Utah. Proc. Utah Mosq. Abate. Assn. 29:32-33.

4. Elbel, Robert E., George T. Crane, Charles H. Calisher, and D. Bruce Francy, 1977. Arbovirus isolations from insects collected in and near southwestern Utah. Proc. Utah Mosq. Abate. Assn. 29:34.

5. Crane, George T., J. Clifton Spendlove, Tairo Fukushima, and Douglas W. Hill, 1978. Evidence for California encephalitis in western Utah residents. Proc. Utah Mosq. Abate. Assn. 30:20.

6. Crane, George T., Robert E. Elbel and Charles H. Calisher, 1978. Isolations of Bunyamwera and California group viruses from western Utah insects. Proc. Utah Mosq. Abate. Assn. 30:21.

7. Elbel, Robert E., George T. Crane, and D. Bruce Francy, 1978. Host-feeding pattern of mosquitoes from Fish Springs, Callao, and Blue Lake, Utah. Proc. Utah Mosq. Abate. Assn. 30:22

APPENDIX F

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